A New Milliped of the Genus *Brevigonus* from South Carolina, with Comments on the Genus and *B. shelfordi* (Loomis) (Polydesmida: Xystodesmidae)

ROWLAND M. SHELLEY
North Carolina State Museum of Natural History,
P.O. Box 27647, Raleigh, North Carolina 27611

ABSTRACT.— *Brevigonus arcuatus*, new species, is characterized by a broadly curved acropodite in which the distal zone is moderately long and possesses either simple or reflexed tips. Its congener, B. shelfordi (Loomis), is distinguished by absence of a distal zone and apical curve, and its abbreviated acropodite terminates at the distal extremity of the peak. An improved generic diagnosis is possible. *Brevigonus* is characterized by the spine at the base of the acropodite, and by the proximal location of the medial flange, which arises on the basal zone and ends on the peak and separates *Brevigonus* from the related genus *Sigmoria*.

In 1980 I attempted to dispose of a long standing taxonomic problem in the Xystodesmidae by erecting the new genus *Brevigonus* for *Cleptoria shelfordi* Loomis. Hoffman (1967) removed this species from *Cleptoria* but did not assign it to another genus. Before publication I collected extensively in and near the range of *shelfordi*, the north side of the Savannah River in the Piedmont Plateau of South Carolina, to try to discover other species for this genus. Finding none, however, I reluctantly concluded that there was no alternative to a monotypic taxon. Two basic gonopodal variants of *shelfordi* were at hand, but they clearly were not reproductively isolated. Consequently, I proposed the genus *Brevigonus* to emphasize what I considered the most distinctive feature of *shelfordi*, its shortened gonopodal acropodities.

I did not know in 1980, however, that a form I was referring to *Sigmoria* was actually closely related to *shelfordi*. I had collected this species several times in piedmont South Carolina but had assigned it to *Sigmoria* because of the overall curvature of the acropodite. Not until I was well into revising *Sigmoria* did I realize that this species was congeneric with *shelfordi*, and by that time the *Brevigonus* paper had been published. The new species shares several features with *shelfordi* that make for a sound generic diagnosis, but shortness of the gonopodal acropodites is unfortunately not one of them. This trait is a specific characteristic of *shelfordi*; the acropodites of the new species are long and form a broadly curved arch, which is the basis for its specific name, *arcuatus*. *Brevigonus* was thus a regrettable choice for a generic name, since it is based on a derived character of only one species and not on a trait shared by all components of the genus. A better name would have emphasized the spines on the basal zones (see terminology of the acro-

podite section in Shelley 1981a) or the proximal locations of the medial flanges, which originate on the basal zones in *shelfordi* and *arcuatus*. Although an inappropriate name, however, *Brevigonus* was validly proposed and must be retained for the taxon encompassing these two species.

There are positive aspects to the belated inclusion of *arcuatus* in *Brevigonus*. Improved diagnoses of the genus and of *shelfordi* are now possible, and certain anatomical features of *shelfordi* can now be more accurately interpreted. Moreover, *arcuatus* evinces a close relationship between *Brevigonus* and *Sigmoria* as opposed to one between *Brevigonus* and *Cleptoria* as previously stated (Shelley 1980). The significance of the flange on the medial surface of the acropodite, for example, was not evident when *shelfordi* was studied alone, because the shortened acropodite of this species terminates at the peak and lacks the distal zones and apical curves present in *arcuatus* and species of *Sigmoria*. *Brevigonus shelfordi* is thus a modified species that lacks the distal 1/3 to 1/2 of the normal apheloriine acropodite. Consequently, the medial flange of *shelfordi* did not previously show any resemblance to the flanges of certain species of *Sigmoria*, but the similarity is obvious in *arcuatus*, since it possesses the distal sections of the acropodite. *Brevigonus* can now be partly defined as an apheloriine genus with a flange on the medial face of the acropodite, arising on the proximal portion of the basal zone and terminating on the proximal portion of the peak. It differs from *Sigmoria* in the more proximal location of the flange, which is located on the peak (arising at the anterior bend) or the distal zone in this genus. The flange is variable in *Brevigonus* and is reduced or vestigial in individuals of both species. The margin is also irregular, and the flange may extend straight across the anterior bend as shown in Figure 3, or curve parallel to the acropodite stem as shown in Figures 8-9 of *shelfordi* in my 1980 paper. The apparent distal lobes on the acropodites of the latter individuals can now be recognized as the termination points of the medial flanges, which end on the distal portions of the acropodites in *shelfordi* only because this structure is shortened. Thus by clarifying the significance of the medial flange, *arcuatus* reveals a close phylogenetic affinity between *Brevigonus* and *Sigmoria*, which is confirmed by one other character—the reflexed tips on males in the southern part of the range of *arcuatus*. These individuals, from Abbeville County, South Carolina, have reflexed tips identical to those of certain species of *Sigmoria*, for instance *S. latior* (Brolemann). No other apheloriine taxa in the southeastern Atlantic lowlands display this termination of the acropodite, and its presence in species of *Sigmoria* and *Brevigonus* is strong evidence of a close relationship between the two genera. No such evidence exists of a relationship between *Brevigonus* and *Cleptoria*. My comments to this effect in 1980 were based on what I

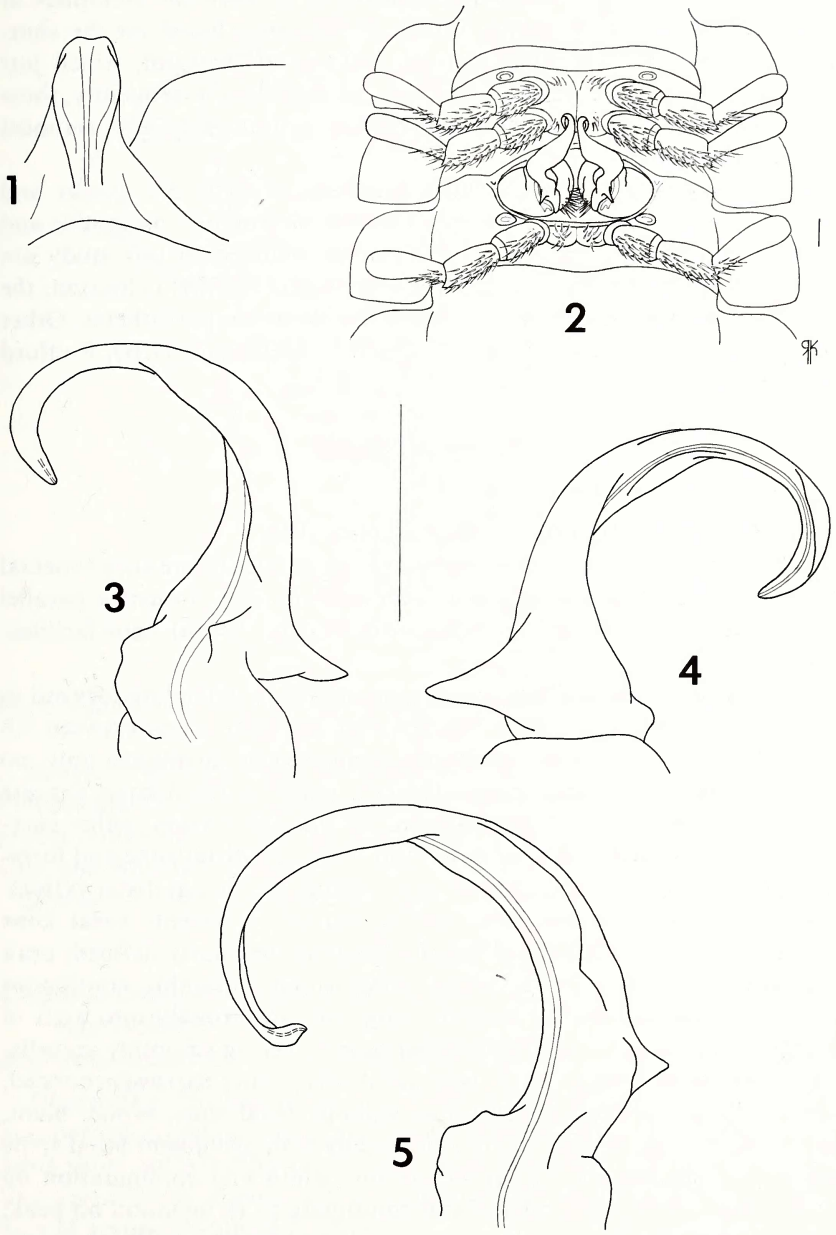

Fig. 1-5. *Brevigonus arcuatus*, new species. 1, process of 4th sternum of holotype, caudal view. 2, gonopods *in situ*, ventral view of paratype. 3, telopodite of left gonopod of holotype, medial view. 4, the same, lateral view. 5, telopodite of left gonopod of male from 5.8 km. SE Lowndesville, Abbeville Co., medial view. Scale line for Fig. 2 = 1.00 mm; line for other Figures = 1.16 mm for 1, 1.40 mm for 3-4, and 1.00 mm for 5.

now realize are only coincidental similarities between the gonopods of *shelfordi* and those of certain forms of *Cleptoria*, based on the shortened acropodites and other derived features of *shelfordi*, which just happen to resemble aspects of *Cleptoria* gonopods. Consequently, these statements about a relationship between *Brevigonus* and *Cleptoria* must now be discounted.

This paper presents amended diagnosis of both *Brevigonus* and *shelfordi*, a description of *arcuatus*, and new information on generic and specific ranges. All specimens of *arcuatus* included in this study are deposited in the North Carolina State Museum (NCSM) collection, the invertebrate catalog numbers of which are shown in parentheses. Other materials are in the collection of Richard L. Hoffman (RLH), Radford University, Radford, Virginia.

Brevigonus Shelley

Brevigonus Shelley 1980:32-34.

Type species.— *Cleptoria shelfordi* Loomis 1944.

Description.— The following comments on gonopods are supplemental to the somatic description in my 1980 account, and present a parallel treatment to the description of *Sigmoria* (Shelley 1981a), thus facilitating comparisons.

Gonopods *in situ* either crossing in midline or extending forward in subparallel arrangement over anterior edge of aperture and between 7th legs. Coxae large, without apophysis, connected by membrane only, no sternal remnant. Prefemur generally large, with or without large, cuneate process arising on dorsal side. Acropodite thick and heavy, either curving broadly through flattened peak into moderate distal zone and forming arc with variable diameter, or terminating abruptly at distal extremity of peak, with distal zone and apical curve absent; basal zone relatively long; anterior bend broad, moderate to poorly defined; peak flattened to gently curved; apical curve broad, smoothly continuous with peak; distal zone moderately long, curving broadly into arch of acropodite and directed toward basal zone, tapering smoothly apically. Termination variable; in forms with distal zone, either narrowly rounded, simple tip, or reflexed tip; in forms without distal zone, broad, blunt, occasionally notched tip. Basal sone usually with prominent basal spine on ventral surface and flange of variable width and configuration on medial face, arising proximally and continuing to termination on peak; latter with or without small acute spur at termination point of flange. Distal zone with remnant of lateral flange extending from proximal portion to about 2/3 length, usually represented by thickened rim near outer margin. Prostatic groove arising in pit on prefemur, crossing to lateral side of acropodite at anterior bend and continuing to terminal opening on simple or reflexed tips, or on distal extremity of peak.

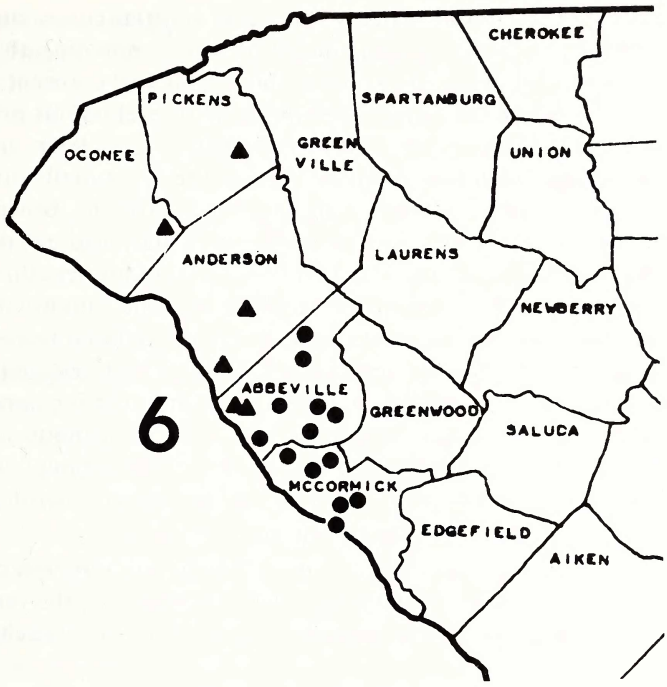

Fig. 6. Distribution of *Brevigonus:* triangles, *arcuatus*; dots, *shelfordi*.

Range.— Western Piedmont Plateau of South Carolina, from eastern Pickens and Oconee counties to central McCormick County. The genus is best represented in the Savannah River Valley of McCormick, Abbeville, and Anderson counties.

Species.— Two.

Brevigonus shelfordi (Loomis)

Cleptoria shelfordi Loomis 1944:172-173, Fig. 4. Chamberlin and Hoffman 1958:28.

Brevigonus shelfordi Shelley 1980:35-41, Figs. 1-13.

Diagnosis.—Distinguished by following features of male gonopods: acropodites crossing *in situ;* prefemoral process present, cuneate; acropodite short, terminating abruptly at distal extremity of peak, distal zone and apical curve absent; with or without sharply acute spur on medial face of acropodite distal to flange.

Description.— As with the generic description, the following comments on gonopods supplement my 1980 description and present an account parallel to those of species of *Sigmoria*.

Gonopods *in situ* with acropodites crossing at midline of aperture, extending over opposite sides of aperture and projecting slightly across

anterior margin. Prefemoral process short and subtriangular, cuneate. Acropodite thick and heavy, curving into peak and terminating abruptly at distal extremity of peak; distal zone and apical curve absent; peak overhanging and extending usually beyond level of prefemoral process, directed subperpendicularly to basal zone; basal zone long, usually about 2/3 of acropodite length, with or without broad, caudally directed spine basally on ventral margin; anterior bend variable, broad and poorly defined to sharp and well defined; peak flattened to slightly curved, relatively short, no more than 1/3 of acropodite length; distal extremity of peak (termination of acropodite) variable—blunt, slightly rounded, or indented with hood-like lobe overhanging basal projection. Medial flange usually present, occasionally reduced and vestigial, arising on basal zone distal to spine, extending beyond anterior bend and terminating on peak, margin irregular. Peak with or without sharply acute spur on medial face distal to flange. Prostatic groove running along medial face of basal zone, crossing to lateral side at anterior bend, terminating on inner corner of basal projection of peak.

Remarks.— The specimens from Oconee County are now referred to *arcuatus*, as mentioned in the ensuing account. Otherwise, the range of *shelfordi*, as represented by the available material, remains unchanged from 1980.

Since it is now apparent that the medial flange is homologous to that of *Sigmoria*, the question arises as to whether the spur might be homologous to the tooth of *latior* and other species of *Sigmoria*. This seems plausible, but the material at hand provides no clues to resolve the issue.

As mentioned, the acropodite of *shelfordi* is merely an extremely shortened one in which the distal zone and apical curve are absent. Given the preponderance of long, curved acropodites in the tribe Apheloriini, such an abbreviated structure can only be interpreted as a derived character.

Brevigonus arcuatus, new species
Figs. 1-5

Type specimens.— Male holotype (NCSM A2075) and 4 M and 2 F paratypes collected by R. M. Shelley and W. B. Jones, 12 June 1978, from Pickens Co., SC, 13.6 km (8.5 mi.) E Pickens, along SC highway 192 at George's Creek. Three M and 2 F, and 7 M and 1 F, paratypes collected at same locality by R. M. Shelley on 8 May 1977 and 2 August 1977, respectively. Male and female paratypes deposited in Florida State Collection of Arthropods and private collection of R. L. Hoffman.

Diagnosis.— Characterized by following features of male gonopods: *in situ* arrangement parallel; prefemoral process absent; acropodite long, curving distally into broad arch, apical curve and distal zone present, without spur on peak; tip of distal zone variable, simple or reflexed.

Holotype.— Length 49.6 mm, maximum width 11.5 mm, W/L ratio 23.2%, depth/width ratio 62.2%. Segmental widths (in mm) as follows:

collum	7.8	10th-13th	11.5
2nd	8.9	14th	11.3
3rd	10.1	15th	11.0
4th	10.4	16th	10.6
5th	11.0	17th	9.4
6th-9th	11.4	18th	6.9

Color in life: paranota bright red, color indented slightly mediad along caudal edges; metaterga and collum glossy black, without stripes.

Somatic features similar to *shelfordi* (see Shelley 1980), with following exceptions: Width across genal apices 5.2 mm, interantennal isthmus broad, 1.8 mm. Antennae moderately long and slender, reaching back to caudal edge of 3rd paranota, relative lengths of antennomeres 2>3>4 = 5>6>1>7. Facial setae as follows: epicranial, interantennal, frontal, and genal absent, clypeal about 10-10, labral about 14-14.

Dorsum very glossy, slightly coriaceous on anterior portions of paranota. Latter moderately depressed, subcontinuous with slope of dorsum. Collum very broad, extending well beyond ends of following tergite. Caudolateral corners of paranota rounded through segment 7, becoming blunt and progressively more acute thereafter.

Process of 4th sternum (Fig. 1) enormous, much longer than widths of adjacent coxae; processes of 5th sternum large, knobs between 4th legs subequal to widths of adjacent coxae, flattened areas between 5th legs produced into knobs, shorter than widths of adjacent coxae; sternum of segment 6 slightly elevated into two small lobes between 6th legs, convexly recessed between 7th legs to accommodate curvatures of acropodites, 7th legs set slightly farther apart than 6th. Postgonopodal sterna bilobed on segments 8-10, with thick patches of stiff setae on lobes, becoming flattened with varying shallow grooves and impressions and fewer setae posteriorly. Coxae with low tubercles beginning on segment 10, becoming spine-like on 14 and continuing posteriorly.

Gonopodal aperture elliptical, 4.1 mm wide and 2.2 mm long at midpoint, strongly indented on anteriolateral edges, sides thickened and elevated above metazonal surface. Gonopods *in situ* (Fig. 2, of paratype) with acropodites in subparallel arrangement, extending forward over anterior edge of aperture between 7th legs, not overlapping or touching. Gonopod structure as follows (Fig. 3-4): prefemoral process absent, with elevated setose ridge at location of process but without sclerotized projection. Acropodite moderately thick and heavy, curving distally into broad arch, flattened at peak, overhanging and extending well beyond level of prefemur; basal zone with large, caudally directed

spine basally on ventral surface and small basal lobe on inner surface above prefemur; anterior bend moderately sharp, located at nearly 1/3 length; peak relatively flat, about 1/4 of acropodite length; apical curve present, broad, located at about 3/4 length; distal zone present, long, curving broadly into arch; tip narrowly rounded, not reflexed, directed toward basal zone. Medial flange arising on basal zone just distal to spine, extending across anterior bend and terminating at midlength of peak, edge curved inward proximally and outward distally, obscurring short section of acropodite stem at anterior bend. Spur absent. Lateral flange present but greatly reduced, forming short rim on distal zone. Prostatic groove running along inner surface of acropodite basally, crossing to lateral side at anterior bend and continuing to tip.

Male paratypes.— The male paratypes agree essentially with the holotype in all particulars.

Female paratype.— Length 48.0 mm, maximum width 11.4mm, W/L ratio 23.8%, depth/width ratio 67.5%. Agreeing closely with holotype in somatic details except paranota more strongly depressed, creating appearance of more highly arched body.

Cyphopods *in situ* with valves visible in aperture, receptacle situated internally against coxae. Receptacle relatively small, located anteriad to and not overlapping valves, surface finely granulate. Valves moderate, inner one slightly larger, surface finely granulate.

Variation.— Several aspects of the gonopods vary. The size of the spine changes, being generally smaller in material from Abbeville County and greatly reduced in one male from Anderson County. The acropodite tends to be thinner and the apical curve broader in the southern specimens, and all males from Abbeville County posses a reflexed tip (Fig. 5). The tip is simple on all other specimens. Specimens from Anderson County have a sharp spine projecting mediad at the base of the medial flange in addition to that at the base of the acropodite, but this structure is absent from the Abbeville County males. All males have an elevated ridge on the prefemur but lack a prefemoral process.

Ecology.— *Brevigonus arcuatus* occurs under thin leaf layers on relatively hard substrates near rivers or creeks. It is sometimes found on the vertical bank of streams and has rarely been taken more than 6 to 9 m from a water source.

Distribution.— Piedmont Plateau physiographic province of central-western South Carolina, from southeastern Pickens to southwestern Abbeville counties. Specimens examined as follows (all collected by the author unless otherwise stated):

SOUTH CAROLINA: *Oconee Co.*— Clemson vic., under dead pig, 2M, F, 18 July 1962, J. A. Payne (RLH). *Pickens Co.*— 13.6 km. (8.5 mi.) E Pickens, along SC hwy. 192 at George's Cr., 3M, 2F, 8 May 1977 (NCSM A 1559); 7M, F, 2 August 1977 (NCSM A1617); and 5M, 2F, 12 June 1978, R. M. Shelley and W. B. Jones (NCSM A2075)

TYPE LOCALITY. *Anderson Co.*— 12.6 km. (7.9 mi.) SE Anderson, along SC hwy. 459 at Rocky R., M, F, 7 May 1977 (NCSM A1550); 10.1 km. (6.3 mi.) NE Iva, along SC hwy. 413 at Rocky R., 2M, 2F, 11 June 1978, R. M. Shelley and W. B. Jones (NCSM A2066); and 6.4 km. (4 mi.) SW Iva, along unnumbered rd. off SC hwy. 187 at Generostee Cr., M, 7 May 1977 (NCSM A1549). *Abbeville Co.*— 5.8 km. (3.6. mi.) SE Lowndesville, along SC hwy. 232 at Deal Cr., M, F, 6 May 1977 (NCSM A1544); and 4.2 km. (2.6 mi.) SW Lowndesville, along SC hwy. 70. 0.5 km. (0.3 mi.) SW jct. SC hwy. 64, M, 6 May 1977 (NCSM A1545).

Remarks.— The unusually large process of the 4th sternum, the longest of any apheloriine milliped known to me, is one of the key features of *arcuatus*. The structure is also longer than the widths of the adjacent coxae in two species of *Croatania* (Shelley 1977), but in these forms it is apically divided and bent anteriad. In *arcuatus*, the process projects directly ventrad and is not divided, although there is a very slight apical indentation. The process is shaped similarly in *shelfordi* but is shorter, being subequal in length to the coxal widths. A long 4th sternal process is thus characteristic of the genus.

Of interest is the fact that, except for *Sigmoria tuberosa* Shelley in the mountains of Swain County, North Carolina, the longest 4th sternal processes in the tribe Apheloriini are found in species in the Piedmont Plateau, and mostly in South Carolina. Hoffman (1967, Fig. 4) showed that the structure is longer than the adjacent coxal widths in *Cleptoria abbotti* Hoffman, which occurs along the southern side of the Savannah River in piedmont Georgia, but otherwise all species demonstrating this condition occur north of the river. However, not all the apheloriine millipeds in South Carolina are so well endowed. The process is shorter than the widths of the adjacent coxae in *Sigmoria latior* (Brolemann), *Cleptoria macra* Chamberlin, and all three species of *Furcillaria*; and is subequal in length in *Sigmoria quadrata* Shelley and *S. laticurvosa* Shelley (Shelley 1981a, 1981b; Hoffman 1967). Consequently, enlargement of this process seems to have evolved independently in four distantly related genera (*Cleptoria, Croatania, Sigmoria,* and *Brevigonus*). Or could this be an ancestral trait that has been retained by certain species in these genera? At present we have insufficient information on other apheloriine taxa to answer this question, since past authors have largely ignored the configuration of the 4th sterna. Having observed sternal variation in many species, however, I incline toward the latter interpretation and suggest that the length, and possibly also the shape, of the 4th sternal process might be indicators of distant phylogenetic relationships. The 4th sternum certainly warrants more attention than it has received, and other authors are encouraged to examine and illustrate it in their species so we will be better able to interpret its significance through a more complete knowledge of variation.

Another unusual feature of *arcuatus* is the presence of both simple and reflexed tips. I know of no other apheloriine species possessing such broad variation, and I consider the forms in Figures 3 and 5 to be conspecific because material from intervening areas in Anderson County displays intermediate conditions. The reflexed tips in Abbeville specimens of *arcuatus*, coupled with the medial flanges in *arcuatus* and some forms of *shelfordi*, are evidence of affinity with *Sigmoria*. However, the more proximal location of the flange on the basal zone in *arcuatus* and *shelfordi*, plus the spine at the base of the acropodite in these two species, justify generic separation from *Sigmoria*.

I include with *arcuatus* the geographically and anatomically disjunct males from Oconee County listed with *shelfordi* in my 1980 paper. Lacking a prefemoral process, and possessing a stronger basal spine and more broadly curved acropodite than other males of *shelfordi*, these males conform more to the description of *arcuatus*. However, they also differ from other specimens of *arcuatus* in having more massive gonopods, broader medial flanges, reduced acropodal curvatures, and broader tips. Perhaps there is a third species of *Brevigonus* in Oconee County, which is unknown except for these specimens. Several trips to Clemson and areas in Oconee County, however, have failed to produce more individuals, and I therefore include this sample under *arcuatus* pending discovery of additional material.

ACKNOWLEDGMENTS.— This study was supported in part by NSF Grant DEB 7702596. Thanks are extended to Renaldo G. Kuhler, NCSM scientific illustrator, for preparing Figure 2.

LITERATURE CITED

Chamberlin, Ralph V., and Richard L. Hoffman. 1958. Checklist of the millipeds of North America. U. S. Natl. Mus. Bull. *212*:1-236.

Hoffman, Richard L. 1967. Revision of the milliped genus *Cleptoria* (Polydesmida: Xystodesmidae). Proc. Biol. Soc. Wash. *124*:1-27.

Loomis, Harold F. 1944. Millipeds principally collected by Professor V. E. Shelford in the eastern and southeastern states. Psych *51*:166-177.

Shelley, Rowland M. 1977. The milliped genus *Croatania* (Polydesmida: Xystodesmidae). Proc. Biol. Soc. Wash. *90*:302-325.

_____. 1980. The status of *Cleptoria shelfordi* Loomis, with the proposal of a new genus in the milliped family Xystodesmidae (Polydesmida). Brimleyana 3:31-42.

_____. 1981a. Revision of the milliped genus *Sigmoria* (Polydesmida: Xystodesmidae). Mem. Am. Entomol. Soc. No. 33, 140 pp.

_____. 1981b. A new xystodesmid milliped genus and three new species from piedmont South Carolina (Polydesmida). Proc. Biol. Soc. Wash. *94*:949-967.

Accepted 17 November 1981